unity, it rises rapidly with temperature until a maximum of 122 is attained at 89° F., beyond which point the values decline.

Proper application of this method calls for a better measure of temperature than is afforded by the daily mean. Lehenbauer's experiment was conducted with plants exposed to constant temperatures. The index of efficiency corresponding to a given daily mean temperature may be far different from that obtained by summing the indices for the components of this mean. Where thermograph records are available, a far more accurate though rather laborious process is to determine the index corresponding to the mean temperature for each two-hour period and taking the average of the values thus obtained. This eliminates practically all of the periods of ineffective temperature instead of combining them with periods of effective temperature and thus reducing the value of the whole. The two-hour period has been chosen as a compromise between accuracy and expediency. Intervals of one hour or even less would yield more accurate results but at the expense of greatly increasing the work of compilation. In Table 1, indices obtained by averaging two-hour periods are compared with those derived from the daily mean temperature. Figure 2 shows the relative temperature efficiency in the various forest types of northern Arizona referred to the growth of maize seedlings. It will be observed that although based upon records of a single season the graphs, as in the case of mean maximum temperature, show a very consistent relationship between the forest types.

TABLE 1.—*Physiological temperature efficiency*

[Yellow-pine type]

June, 1918	Daily temperature		Physiological efficiency based on—	
	Maximum	Mean	Daily mean temperature	Temperature by 2-hour periods
	°F.	°F.		
1	68.8	52.8	9.22	17.22
2	75.5	54.2	10.33	28.01
3	75.7	56.5	14.44	31.23
4	77.0	56.3	12.78	37.97
5	76.2	57.05	14.44	38.73
6	79.0	58.45	16.11	39.04
7	77.7	60.25	19.88	41.22
8	77.5	59.65	19.88	37.47
9	83.0	63.25	27.11	51.50
10	86.3	67.15	41.33	56.97
Total	776.7	585.6	185.52	379.36
Mean	77.7	58.5		
11	88.9	68.85	50.83	66.12
12	88.2	68.0	46.00	45.87
13	81.9	66.4	37.22	44.29
14	81.2	65.45	33.33	40.56
15	76.6	61.95	24.33	31.22
16	76.9	62.5	27.11	31.99
17	81.0	66.25	37.22	37.77
18	79.0	63.35	27.11	34.54
19	78.0	63.45	27.11	31.71
20	79.0	63.35	27.11	43.10
Total	810.7	649.55	337.37	407.17
Mean	81.1	64.96		
21	77.8	66.15	37.22	28.80
22	70.0	61.15	22.00	21.00
23	73.5	62.75	27.11	28.65
24	77.6	61.4	32.00	33.47
25	81.0	64.75	33.33	44.46
26	86.3	67.4	41.33	61.48
27	86.5	70.5	60.33	68.45
28	86.8	65.7	37.22	55.90
29	83.5	66.25	37.22	42.95
30	82.1	64.05	30.00	36.46
Total	805.1	650.10	347.76	421.62
Mean	80.5	65.01		
Monthly total	2,392.5	1,885.25	870.65	1,208.15
Monthly mean	79.8	62.8		

Since plants vary in their heat requirements, indices of efficiency should be determined for each species concerned, or at least for several groups of species having approximately the same requirements. In forestry, for instance, separate determinations should be made for characteristic species such as western yellow pine, Douglas fir, and Engelmann spruce.

Of all the methods here described, the method of physiological indices is the only one which is based directly on the response of plants to heat. This method promises to be very useful when supported by thermograph records and experimental data on the response of various species. Without these data, however, the values obtained are only a rough index. Under these circumstances, which indeed are those generally encountered, the mean maximum temperature is believed to be the most practical index available. In the mountains of the Southwest it has proven far more consistent and expressive than mean temperature, and while it may not prove equally superior in regions of low daily range and higher temperatures generally, it will undoubtedly prove a valuable adjunct to records of mean temperature. As

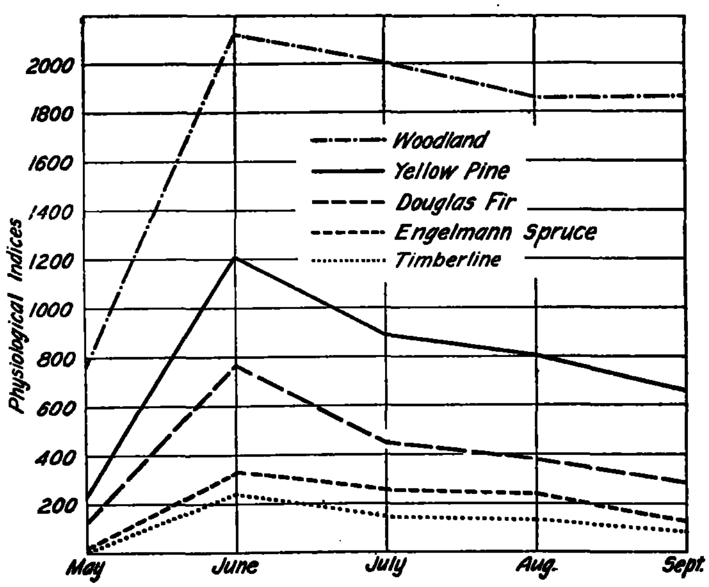

FIG. 2.—Physiological tempetraure efficiency, 1918

compared to the method of summing daily means above 43° F. or any other minimum limit, it has the advantage of greater simplicity and consistency.

In conclusion I wish to recommend to ecologists that they consider the mean maximum temperature where thermograph records are not to be had. Obviously, the mean maximum is to be regarded only as an index rather than a complete measure of heat conditions. To Weather Bureau officials I wish to suggest that they use every effort to include the mean maximum in their temperature summaries.

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OUR PRESENT KNOWLEDGE CONCERNING THE ATMOSPHERIC DISTURBANCES OF RADIOTELEGRAPHY [1]

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Our present knowledge concerning the atmospheric disturbances of radiotelegraphy is very limited, but in the following I have attempted to make a brief résumé of the known facts and generally accepted hypotheses.

[1] Subreport of committee on atmospheric-electric phenomena and measurements in the troposphere and stratosphere presented at the annual meeting of the section of terrestrial magnetism and electricity of the American Geophysical Union, Apr. 18, 1923.

[2] Reprinted from Bull. of the National Research Council, vol. 7, pt. 5, No. 41. Washington, 1924, pp. 127-130.

Atmospheric disturbances, popularly called static, form the chief obstacle to the progress of radio telegraphy and telephony. They give rise to troublesome noises in the telephone receivers, which frequently make the reception of signals at great distances impossible, even in the case of the most powerful transmitting stations. They are generally most violent during the warmer months, and are especially severe in the Tropics. They differ in strength from year to year, and their intensity usually increases rapidly with the wave length to which the receiving apparatus is tuned.

The disturbances have been classified by Eccles according to their sound in the telephones as clicks, hissing, rumbling, and crashing.

The clicks and hissing are of comparatively little importance, the first being thought to be due to distant flashes of lightning and the second to the discharge of dust, snow, or rain, striking the antenna.

The rumbling type (grinders), which is the most common type of disturbance, is generally believed to consist of strongly damped electrical wave trains or of untuned single pulses. That this type of disturbance has sometimes a certain amount of tuning is shown by the fact that the individual discharges are not always heard simultaneously at different wave lengths, but it is believed that the discharges are so numerous that, since they occur at different frequencies, they form a kind of disturbance spectrum and thus appear in the receiving apparatus at every wave length to which the antenna may be tuned. While nothing is definitely known as to the exact nature of the source of the rumbling disturbances, it is believed that they are probably produced in the upper atmosphere by electrical readjustments. The resulting electrical waves expand in a more or less spherical manner until the lower portions of the wave front strike the earth, when they spread out, guided by the earth, and move off with a wave front which soon becomes practically vertical exactly like the electrical waves started from the transmitter of an airplane. The more powerful rumbling disturbances seem to come frequently from definite centers which often appear to lie above mountainous regions; for example, a large proportion of these disturbances which have been noted along the coast of Oregon and Washington appear to come from the direction of Mount Rainier. Other well-marked centers have been observed in the mountains back of San Francisco and San Diego. The centers mentioned appear to be nearly constant in position and have been continuously active since their first discovery in 1920. It is believed that there is also a center of great energy somewhere in southern Mexico which frequently produces receiving difficulties throughout the eastern United States, where disturbances from the Allegheny Mountains are also noticed. Among other reported sources of rumbling disturbances are large cities, perhaps on account of their ascending currents of heated air, thunderclouds, though here they are apparently unconnected with the visible lighting flashes, which produce clicks, and the advancing edges of rain areas. It may be said that, in general, the rumbling disturbances more commonly originate above the land, as ships far out at sea are comparatively little troubled by them.

The intensities of disturbances of the rumbling type seem to be closely connected with the seasonal variations in the height of the sun's path. Some observations in Africa, reported by Dr. R. B. Goldschmidt and R. Braillard, tend to show that radio stations close to the Equator have two well-marked maxima during the year at the time when the path of the sun passes through the zenith.

When the disturbances are directive and come from a direction different from that of the signal which is being received, it is often possible to eliminate a large part of the disturbances and thus improve the reception by making use of unidirectional receiving apparatus. Unfortunately it generally happens that there are secondary centers, such as local clouds or near-by mountains, which act upon the receiving station from several directions at the same time.

Some situations have been found, notably in California, where the disturbances come almost entirely from one point. In these places reception from the direction of the Pacific Ocean can be made nearly free from atmospheric troubles.

In addition to the rumbling disturbances, crashes are often heard in the telephones which seem to differ in origin and character from the rumbling type. The difference in sound of the two types is not easily distinguishable for untrained observers, since the rumbling is frequently preceded by a crashing noise. The true crashing disturbance, however, is not followed by rumbling. There is little evidence that the crashes are directive in character, while there are a number of observations which tend to show that they occur simultaneously at widely distant stations; for example, at San Francisco and Honolulu. It has been suggested that they may be connected with solar outbursts, although there is little direct proof to this effect. Sometimes they appear to occur in large number on days when earth-current disturbances are noted on telegraph and cable lines. It is also thought by radio operators that the crashes are entirely untuned in character, since the individual crashes are observed frequently simultaneously on widely different wave lengths.

THE CHIEF PROBLEMS OF ATMOSPHERIC DISTURBANCES

1. There is need of systematic daily observations on the intensity of the atmospheric disturbances at a large number of points in all parts of the earth. It is desirable where possible, to have this intensity measured in terms of electric voltage on the antenna expressed in volts per meter height. Eventually recording apparatus should be devised for automatically taking these observations.

2. Measurements are also needed on the prevailing direction of the directive types of disturbances at widely scattered stations. As soon as possible recording instruments should be used for this purpose. A direction recorder has, I believe, already been constructed in England. These observations will probably show daily and seasonal shifts of prevailing direction and will eventually indicate certain points as disturbance centers.

3. When these disturbance centers are identified, a study should be made of the meteorological and electrical conditions prevailing, which will perhaps throw light on the conditions under which the disturbances are produced.

4. Observations should be made on the simultaneity of individual disturbances at widely distant points, identifying as far as possible the type of disturbance.

5. The question of the directivity of the crashing type should be settled.

When sufficeint information regarding these points has been collected, comparisons can be made between the disturbances and other natural phenomena, solar activity, the earth's electrical and magnetic phenomena, and those of seismology and volcanology.